ENGLISH
TRANSLATION
OF INTERNATIONAL
APPLICATION AS FILED

DESCRIPTION

HIGH-FREQUENCY COMPOSITE PART

Technical Field

The present invention relates to a high-frequency composite part and more particularly to a high-frequency composite part usable in a plurality of different mobile communication systems.

Background Art

Presently, in Europe, as a mobile communication device, a dual-band portable telephone which can be operated in a plurality of frequency bands, for example, in the DCS system using a 1.8 GHz band and the GSM system using a 900 MHz band is proposed.

Fig. 18 shows a part of the structure of a general dual-band portable telephone and the part is composed of an antenna 1, a diplexer 2, and two signal paths of a DCS system 3 (1.8 GHz band) and a GSM system 4 (900 MHz band).

The diplexer 2 selects a transmission signal from the DCS system 3 or the GSM system 4 in transmission and selects a reception signal to the DCS system 3 or the GSM system 4 in reception. The DCS system 3 is composed of a high-frequency switch 3a for separating a transmission portion Txd and a reception portion Rxd and a filter 3b for making the fundamental frequency of the DCS system pass through and for attenuating the second and third harmonics. In the same way, the GSM system 4 is also composed of a high-frequency switch 4a for separating a transmission portion Txg and a reception portion Rxg and a filter 4b for making the fundamental frequency of the GSM system pass through and for attenuating the third harmonics.

Now, in recent years, a balanced-type (balanced-output type) high-frequency composite part having two signal terminals in the reception portion is proposed and, in such a balanced type, the impedance

matching to an LNA low-noise amplifier) is required.

In Patent Document 1, as shown in Fig. 19, it is disclosed that an inductor 6 is disposed in parallel between the balanced output terminals Rx of a bandpass filter made up of a balanced-output type surface acoustic wave filter. However, it is different to set a desired impedance (complex impedance, in particular). According to the knowledge of the present inventor, in order to lower the impedance, it is required to insert a capacitor in series to each of the balanced output terminals, and, to increase the impedance, it is required to insert one more inductor in parallel between the balanced output terminals in addition to the above-described capacitors. However, when capacitors and inductors as separate parts are added between such a high-frequency composite part and an LNA, the number of parts and the mounting area increase to result in upsizing the equipment, and the matching between the bandpass filter 5 and the LNA becomes more complicated.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2003-142981

Disclosure of Invention

Accordingly, it is an object of the present invention to provide a high-frequency composite part in which a desired impedance can be easily set in the high-frequency composite part itself, no matching adjustment to an LNA is required, the number of parts is reduced, and reduction in size can be made.

Furthermore, it is another object of the present invention to further provide a high-frequency composite part in which interference between the elements is prevented and which shows excellent characteristics.

In order to attain the above objects, a high-frequency composite part according to the present invention comprises a switch for

selectively switching a signal path between an antenna terminal and a transmission-side input terminal and a signal path between the antenna and a reception-side balanced output terminal; an LC filter having an inductor and capacitors disposed between the antenna terminal and the transmission-side input terminal; a surface acoustic wave filter disposed between the switch and the reception-side balanced output terminal; and a matching element having an inductor and capacitors disposed between the surface acoustic wave filter and the reception-side balanced output terminal. In the high-frequency composite part, the switch, the LC filter, the surface acoustic wave filter, and the matching element are integrated in an integrated block having a plurality of dielectric layers laminated.

In the high-frequency composite part according to the present invention, since a matching element having an inductor and capacitors is contained between a surface acoustic wave filter and a reception-side balanced output terminal, it becomes possible to freely set the impedance of the reception-side balanced output terminal by an appropriate combination of the inductor and capacitors. Moreover, since the inductor and capacitors are integrated in a laminated block with other circuit parts, in comparison with the case where the inductor and capacitors are discretely arranged on a printed-circuit board, the mounting area on the printed-circuit board can be reduced, and also the distance between the surface acoustic wave filter and the matching element is minimized and the loss between the filter and the matching element can be suppressed to improve high-frequency characteristics.

Now, an important thing when the switch, the LC filter, the surface acoustic wave filter, and the matching element are integrated in a laminated block having a plurality of dielectric layers laminated is to make arrangement so that the interference between the matching element and the LC filter can be prevented. In particular, regarding

the inductance of the matching element, a high Q value and stability are required.

Then, in a high-frequency composite part according to the present invention, it is desirable that the inductor of the matching element be formed in a first area of the laminated block, and that the inductor and capacitors of the LC filter be formed in a second area different from the first area when seen from the top.

In the same way, it is desirable that the inductor of the matching element be mounted on the surface of the laminated block and that the inductor and capacitors of the LC filter be contained inside the laminated block. Furthermore, it is desirable that a ground electrode be disposed between the inductor of the matching element and the inductor and capacitors of the LC filter. Or it is desirable that a shunt capacitor of the capacitors of the LC filter be formed in the vicinity of the lowest layer of the laminated block.

The inductor and capacitances of the matching element are formed on the surface of the laminated block, and the inductor of the matching element may be disposed so as to be directly next to the capacitors of the matching element not through any other element.

Furthermore, the surface acoustic wave filter may be a balanced-type surface acoustic wave filter having balanced output ports or the surface acoustic wave filter may be an unbalanced-type surface acoustic wave filter having unbalanced output ports. When the surface acoustic wave filter is of a balanced type, the inductor of the matching element is connected in parallel between the balanced output ports and the capacitors of the matching element are connected in series to the balanced output ports. Furthermore, when the surface acoustic wave filter is of an unbalanced type, the inductor and capacitors of the matching element function as a balun.

Moreover, a high-frequency composite part according to the present invention can be constituted as a high-frequency composite part of a

dual-band type in which signals in two different frequency bands can be processed. In such a high-frequency composite part of a dual-band type, a diplexer branching a signal path for a first frequency band and a signal path for a second frequency band different from the first frequency band is contained at the rear stage of the antenna terminal; in the signal path for a first frequency band, a first switch for selectively switching a signal path between the antenna terminal and a first transmission-side input terminal and a signal path between the antenna terminal and a first reception-side balanced output terminal, a first LC filter having an inductor and capacitors disposed between the first switch and the first transmission-side input terminal, a first surface acoustic wave filter disposed between the first switch and the first reception-side balanced output terminal, and a first matching element having an inductor and capacitors disposed between the first surface acoustic wave filter and the first reception-side balanced output terminal are contained; in the signal path for a second frequency band, a second switch for selectively switching a signal path between the antenna terminal and a second transmission-side input terminal and a signal path between the antenna terminal and a second reception-side balanced output terminal, a second LC filter having inductors and capacitors disposed between the second switch and the second transmission-side input terminal, a second surface acoustic wave filter disposed between the second switch and the second reception-side balanced output terminal, and a second matching element having an inductor and capacitors disposed between the second surface acoustic wave filter and the second reception-side balanced output terminal are contained; and the diplexer, the first and second switches, the first and second LC filters, the first and second surface acoustic wave filters, and the first and second matching elements are integrated in a laminated block having a plurality of dielectric layers laminated.

Moreover, a high-frequency composite part according to the present invention can be constituted as a high-frequency composite part of a triple-band type in which signals in three different frequency bands can be processed. In such a high-frequency composite part of a triple-band type, a diplexer branching a signal path for a first frequency band and a signal path for a second frequency band different from the first frequency band is provided at the rear stage of the antenna terminal; in the signal path for a first frequency band, a first switch for selectively switching a signal path between the antenna terminal and a first transmission-side input terminal and a signal path between the antenna terminal and a first reception-side balanced output terminal, a first LC filter having an inductor and capacitors disposed between the first switch and the first transmission-side input terminal, a first surface acoustic wave filter disposed between the first switch and the first reception-side balanced output terminal, and a first matching element having an inductor and capacitors disposed between the first surface acoustic wave filter and the first reception-side balanced output terminal are contained; in the signal path for a second frequency band, a second switch for selectively switching a signal path between the antenna terminal and a second transmission-side input terminal and a signal path between the antenna terminal and second and third reception-side balanced output terminals, a second LC filter having inductors and capacitors disposed between the second switch and the second transmission-side input terminal, a duplexer branching a signal path disposed between the second switch and the second reception-side balanced output terminal and a signal path disposed between the second switch and the third reception-side balanced output terminal, a second surface acoustic wave filter disposed between the duplexer and the second reception-side balanced output terminal, a second matching element having an inductor and capacitors disposed between the second

surface acoustic wave filter and the second reception-side balanced output terminal, a third surface acoustic wave filter disposed between the duplexer and the third reception-side balanced output terminal, and a third matching element having an inductor and capacitors disposed between the third surface acoustic wave filter and the third reception-side balanced output terminal are contained; and the diplexer, the first and second switches, the first and second LC filters, the first, second, and third surface acoustic wave filters, and the first, second, and third matching elements are integrated in a laminated block having a plurality of dielectric layers laminated.

Brief Description of the Drawings

Fig. 1 is a block diagram showing the basic structure of a first embodiment of a high-frequency composite part according to the present invention.

Fig. 2 is an equivalent circuit diagram of the first embodiment.

Fig. 3 is a block diagram showing the basic structure of a second embodiment of a high-frequency composite part of the present invention.

Fig. 4 is an equivalent circuit diagram of the second embodiment.

Fig. 5 is a schematic illustration showing the shape of electrodes formed on each sheet layer (first to eighth layers from the lower) of a ceramic multilayer substrate of the second embodiment.

Fig. 6 is a schematic illustration showing the shape of electrodes formed on each sheet layer (ninth to fifteenth layers from the lower) of a ceramic multilayer substrate of the second embodiment.

Fig. 7 is a schematic illustration showing the shape of electrodes formed on each sheet layer (sixteenth and seventeenth layers from the lower) of a ceramic multilayer substrate of the second embodiment.

Fig. 8 is a top view showing the mounting state of each circuit element on the surface of the ceramic multilayer substrate of the second embodiment.

Fig. 9 is a block diagram showing the basic structure of a third embodiment of a high-frequency composite part according to the present invention.

Fig. 10 is an equivalent circuit diagram of the third embodiment.

Fig. 11 is an equivalent circuit diagram of a fourth embodiment of a high-frequency composite part according to the present invention.

Fig. 12 is a schematic illustration showing the shape of electrodes formed on each sheet layer (first to eighth layers from the lower) of a ceramic multilayer substrate of the fourth embodiment.

Fig. 13 is a schematic illustration showing the shape of electrodes formed on each sheet layer (ninth to fifteenth layers from the lower) of a ceramic multilayer substrate of the fourth embodiment.

Fig. 14 is a schematic illustration showing the shape of electrodes formed on each sheet layer (sixteenth and seventeenth layers from the lower) of a ceramic multilayer substrate of the fourth embodiment.

Fig. 15 is a top view showing the mounting state of each circuit element on the surface of the ceramic multilayer substrate of the fourth embodiment.

Fig. 16 is an equivalent circuit diagram of a fifth embodiment of a high-frequency composite part according to the present invention.

Fig. 17 is an equivalent circuit diagram of a sixth embodiment of a high-frequency composite part according to the present invention.

Fig. 18 is a block diagram showing a switching circuit of a related dual-band portable telephone.

Fig. 19 is a block diagram showing the outline of the structure of a related bandpass filter.

Best Mode for Carrying Out the Invention

Hereinafter, the embodiments of a high-frequency composite part according to the present invention are described with reference to the

accompanied drawings.

First embodiment (see Figs. 1 and 2)

In a high-frequency composite part of a single-band type of the present first embodiment, as the characteristic structure is shown in a block diagram of Fig. 1, an inductor L is connected in parallel between the balanced output portion of a balanced-typed surface acoustic wave filter SAW and the reception-side balanced output terminal Rx, and capacitors C1 and C2 are connected in series, respectively.

In detail, as shown in an equivalent circuit diagram of Fig. 2, the high-frequency composite part is, on the whole, composed of a high-frequency switch 11, an LC filter 12, a balanced-type surface acoustic wave filter SAW, and a matching element 13.

The high-frequency switch 11 is for selectively switching a signal path between an antenna terminal ANT and a transmission-side input terminal Tx and a signal path between the antenna terminal ANT and a reception-side balanced output terminal Rx. The LC filter 12 is disposed between the high-frequency switch 11 and the transmission-side input terminal Tx and is a low-pass filter including an inductor GLt1 and capacitors. The capacitors of the low-pass filter are composed of a capacitor GC connected in parallel to the inductor GLt1 and two grounding capacitors (shunt capacitors) GCu1 and GCu2 connected to the ground.

In the matching element 13, as described above, the inductor L is connected in parallel and the capacitors C1 and C2 are connected in series, respectively, between the balanced output portion of the surface acoustic wave filter SAW and the reception-side balanced output terminal Rx.

Furthermore, in the present first embodiment, the above-described high-frequency switch 11, LC filter 12, surface acoustic wave filter SAW, and matching element 13 are united in a laminated block in which

a plurality of dielectric layers are laminated.

The high-frequency composite part of the present first embodiment which is of a single-band type is included in high-frequency composite parts of second and third embodiments of a dual-band type and a high-frequency composite part of a fourth embodiment of a triple-band type as a part of them. Accordingly, the more detailed structure and operation of the present first embodiment are made clear through the second, third, fourth, fifth, and sixth embodiments to be described later.

Second embodiment (see Figs. 3 to 8)

A high-frequency composite part of the present second embodiment is a high-frequency composite part (front-end module) of a dual-band type having GSM and DCS systems as its characteristic structure is shown in a block diagram in Fig. 3. Inductors Lg and Ld are connected in parallel between the balanced output portions of balanced-type surface acoustic wave filters SAWg and SAWd and reception-side balanced output terminals Rxg and Rxd, and capacitors C1g and C2g, and C1d and C2d are connected in series, respectively.

In detail, as shown in an equivalent circuit diagram of Fig. 4, the high-frequency composite part contains a diplexer 20 branching a GSM-system signal path and a DCS-system signal path at the rear stage of the antenna terminal ANT. Moreover, the GSM system contains a first high-frequency switch 11G, a first LC filter 12G, the first balanced-type surface acoustic wave filter SAWg, and a first matching element 13G. In the same way, the CS system also contains a second high-frequency switch 11D, a second LC filter 12D, the second balanced-type surface acoustic wave filter SAWd, and a second matching element 13D.

The first high-frequency switch 11G selectively switches a signal path between the antenna terminal ANT and a first transmission-side input terminal Txg and a signal path between the antenna terminal ANT

and a first reception-side balanced output terminal Rxg. The first LC filter 12G is disposed between the first high-frequency switch 11G and the first transmission-side input terminal Txg. The first surface acoustic wave filter SAWg is disposed between the first high-frequency switch 11G and the first reception-side balanced output terminal Rxg.

In the first matching element 13G, the inductor Lg is connected in parallel on the side of the first surface acoustic wave filter SAWg, and the capacitors C1g and C2g are connected in series between the inductor Lg and the reception-side balanced output terminal Rxg, respectively.

The second high-frequency switch 11D selectively switches a signal path between the antenna terminal ANT and a second transmission-side input terminal Txd and a signal path between the antenna terminal ANT and a second reception-side balanced output terminal Rxd. The second LC filter 12D is disposed between the second high-frequency switch 11D and the second transmission-side input terminal Txd. The second surface acoustic wave filter SAWd is disposed between the second high-frequency switch 11D and the second reception-side balanced output terminal Rxd.

In the second matching element 13D, an inductor Ld is connected in parallel on the side of the second surface acoustic wave filter SAWd, and the capacitors C1d and C2d are connected in series between the inductor Ld and the reception-side balanced output terminal Rxd, respectively.

The diplexer 20 selects a transmission signal from the DCS system or the GSM system in the case of transmission and selects a reception signal to the DCS system or the GSM system in the case of reception. The antenna terminal ANT is connected to a first port P11 of the diplexer 20, the first port P31g of the first high-frequency switch 11G is connected to a second port P12, and the first port P31d of the second high-frequency switch 11D is connected to a third port P13.

In the GSM system, a first port P21g of the first LC filter 12G is connected to a second port P32g of the first high-frequency switch 11G, and the first surface acoustic wave filter SAWg is connected to a third port P33g. The first transmission-side input terminal Txg is connected to a second port P22g of the first LC filter 12G.

In the DCS system, a first port P21d of the second LC filter 12D is connected to a second port P32d of the second high-frequency switch 11D, and the second surface acoustic wave filter SAWd is connected to a third port P33d. The transmission-side second input terminal Txd is connected to a second port P22d of the second LC filter 12D.

The diplexer 20 is composed of inductors Lt1 and Lt2, and capacitors Cc1, Cc2, Ct1, Ct2, and Cu1. A parallel circuit made up of the inductor Lt1 and the capacitor Ct1 is connected between the first port P11 and the second port P12, and the side of the second port P12 of the parallel circuit is grounded through the capacitor Cu1. Furthermore, the capacitors Cc1 and Cc2 are connected in series between the first port P11 and the third port P13, and the connection point between them is grounded through the inductor Lt2 and the capacitor Ct2.

The first high-frequency switch 11G is composed of diodes GD1 and GD2 as switching elements, inductors GSL1 and GSL2, capacitors GC5 and GC6, and a resistor RG. The diode GD1 is connected between the first port P31g and the second port P32g so that the anode may be on the side of the first port P31g, and the cathode is grounded through the inductor GSL1. The cathode of the diode GD2 is connected to the first port P31g through the inductor GSL2, and the anode is grounded through the capacitor GC5. A control terminal Vc1 is connected to the connection point between the diode GD2 and the capacitor GC5 through the resistor RG. Furthermore, the connection point between the cathode of the diode GD2 and the third port P33g is grounded through the capacitor GC6.

The second high-frequency switch 11D is composed of diodes DD1 and DD2 as switching elements, inductors DSL1, DSL2, and DSLt, capacitors DC6, DC7, and DCt1, and a resistor RD. The diode DD1 is connected between the first port P31d and the second port P32d so that the anode may be on the side of the first port P31d, and the cathode is grounded through the inductor DSL1. Furthermore, a series circuit of the capacitor DCt1 and the inductor DSLt is connected in parallel to the diode DD1 between the first port P31d and the second port P32d. The cathode of the diode DD2 is connected to the first port P31d through the inductor DSL2, and the anode is grounded through the capacitor DC5. A control terminal Vc2 is connected to the connection point between the diode DD2 and the capacitor DC5 through the resistor RD. Furthermore, the cathode of the diode DD2 is connected to the third port P33d through the capacitor DC6, and the connection point between the cathode and the capacitor DC6 is grounded through the capacitor DC7.

In the first LC filter 12G, a parallel circuit of an inductor GLt1 and a capacitor GCc1 is connected between the first port P21g and the second port P22g. Both ends of the inductor GLt1 are grounded through capacitors GCu1 and GCu2, respectively.

In the second LC filter 12D, a parallel circuit of an inductor DLt1 and a capacitor DCc1 and a parallel circuit of an inductor DLt2 and a capacitor DCc2 are connected in series between the first port P21d and the second port P22d. Both ends of the inductor DLt1 are grounded through capacitors DCu1 and DCc2, respectively.

Figs. 5 to 7 show capacitor electrodes, strip line electrodes, etc., formed by screen printing, etc., on each sheet layer constituting a ceramic multilayer substrate of a high-frequency composite part of the present second embodiment. The ceramic multilayer substrate is formed in such a way that first to seventeenth sheet layers 61a to 61q made of ceramics having barium oxide, aluminum

oxide, and silica as main components are laminated in order from the lower and sintered at a temperature of 1000°C or less.

Various terminal electrodes for external connection are formed on the first sheet layer 61a. A ground electrode G1 is formed on the second sheet layer 61b, the electrodes for the capacitors GCu1, GCu2, Ct2, and GC5 are formed on the third sheet layer 61c to form capacitances together with the ground electrode G1. A ground electrode G2 is formed on the fourth sheet layer 61d, and the electrodes for the capacitors DCu1 and DCu2 are formed on the fifth sheet layer 61e to form capacitances with the ground electrode G2.

The inductors Lt1, Lt2, DLt1, DLt2, GLt1, DSL1, and DSL2 are formed by stripline electrodes on the seventh and ninth sheet layers 61g and 61i and these are connected by via holes. Moreover, the inductors Lt1, Lt2, DLt1, DLt2, GLt1, and DSL2 are formed by stripline electrodes on the eleventh sheet layer 61k and those are connected to the same electrodes on the lower layers by via holes.

The electrodes of the capacitors Ct1 and DCc1 are formed on the twelve sheet layer 61l, and the electrodes of the capacitors Ct1, Cc1, DCt1, and GCc1 and the ground electrode G3 are formed. The electrodes of the capacitors Cc1, DCt1, GCc1, and DC5 are formed on the fourteenth sheet layer 61n. The electrodes of the capacitors Cc2 and DCt1 and the ground electrode G4 are formed on the fifteenth sheet layer 61o.

As shown in Fig. 8, various connection terminal electrodes are formed on the surface of the seventeenth sheet layer 61q constituting the surface of the ceramic multilayer substrate 50. Then, on the surface, the first and second surface acoustic wave filters SAWg and SAWd and the diodes GD1, GD2, DD1, and DD2 are mounted, and the inductor Lg and the capacitors C1g and C2g constituting the first matching element 13G and the inductor Ld and the capacitors C1d and C2d constituting the second matching element 13D are mounted.

Moreover, the resistors RG and RD and the inductors DSL1, DSLt, and GSL1 are mounted on the surface of the ceramic multilayer substrate 50.

Here, the operation of the high-frequency composite part having the circuit structure shown in Fig. 4 is described. First, when a transmission signal of the DCS system (1.8 MHz band) is sent, in the second high-frequency switch 11D, the transmission signal of the DCS system passes through the second LC filter 12D, the second high-frequency switch 11D, and the diplexer 20 and is transmitted from the antenna terminal ANT connected to the first port P11 of the diplexer 20 in such a away that, for example, 3 V is applied to the control terminal Vc2 to turn on the diodes DD1 and DD2.

At this time, in the first high-frequency switch 11G of the GSM system, the transmission signal of the GSM system is made not to be transmitted in such a way that, for example, 0 V is applied to the control terminal Vc1 to turn off the diode GD1. Furthermore, the transmission signal of the DCS system is made not to enter the first transmission-side input terminal Txg and the first reception-side balanced output terminal Rxg of the GSM system due to the connection of the diplexer 20. Moreover, the second and third harmonics of the DCS system are attenuated in the second LC filter 12D of the DCS system.

Next, when a transmission signal of the GSM system (900 MHz band) is sent, in the first high-frequency switch 11G, the transmission signal of the GSM system passes through the first LC filter 12G, the first high-frequency switch 11G, and the diplexer 20 and is transmitted from the antenna terminal ANT connected to the first port P11 of the diplexer 20 in such a way that, for example, 3 V is applied to the control terminal Vc1 to turn on the diodes GD1 and GD2.

At this time, in the second high-frequency switch 11D of the DCS system, the transmission signal is made not to be transmitted in such a way that, for example, 0 V is applied to the control terminal Vc2 to

turn off the diode DD1. Furthermore, the transmission signal of the GSM system is made not to enter the second transmission-side input terminal Txd and the second reception-side balanced output terminal Rxd of the DCS system due to the connection of the duplexer 20.

Moreover, the second harmonic of the GSM system is attenuated in the low-pass filter made up of the capacitor Ct1, the inductor Lt1, and the shunt capacitor Cu1 of the diplexer 20 and the third harmonic of the GSM system is attenuated in the first LC filter 12G of the GSM system.

Next, when reception signals of the DCS system and the GSM system are received, in the second high-frequency switch 11D of the DCS system, a reception signal of the DCS system is made not to enter the second transmission-side input terminal Txd in such a way that, for example, 0 V is applied to the control terminal Vc2 to turn off the diodes DD1 and DD2 and, in the first high-frequency switch 11G of the GSM system, a reception signal of the GSM system is made not to enter the first transmission-side input terminal Txg of the GSM system in such a way that 0 V is applied to the control terminal Vc1 to turn off the diodes GD1 and GD2. Then, the signals input from the antenna terminal ANT are output to the reception-side balanced output terminal Rxd of the DCS system and the reception-side balanced output terminal Rxg of the GSM system, respectively.

Furthermore, the reception signal of the DCS system is made not to enter the GSM system and the reception signal of the GSM system is made not to enter the DCS system due to the connection of the diplexer 20.

In the high-frequency composite part of the present second embodiment, since the matching elements 13G and 13D including the inductors Lg and Ld and the capacitors C1g, C2g, C1d, and C2d are contained between the surface acoustic wave filters SAWg and SAWd and the reception-side balanced output terminals Rxg and Rxd, it becomes

possible freely to set the impedance of the reception-side balanced output terminals Rxg and Rxd by appropriate combination of the inductors and capacitors.

Furthermore, since the inductors Lg and Ld and the capacitors C1g, C2g, C1d, and C2d are integrated in the ceramic laminated substrate together with the other circuit parts, in comparison with the case where such inductors and capacitors are discretely disposed on a printed circuit board, the mounting surface on the printed substrate can be reduced and simultaneously the distance between the surface acoustic wave filters SAWg and SAWd and the matching elements 13G and 13D is minimized and the loss between the filters SAWg and SAWd and the matching elements 13G and 13D can be suppressed to improve the high-frequency characteristics.

Furthermore, since the inductors Lg and Ld of the matching elements 13G and 13D are formed so as not to overlap with the inductors and capacitors of the LC filters 12G and 12D in the ceramic laminated substrate when seen from the top, the isolation between the transmission and reception lines is secured and the mixture of a signal can be prevented. Since the inductors Lg and Ld of the matching elements 13G and 13D are mounted on the surface of the ceramic laminated substrate, the same effect can be attained by the inductors and capacitors of the LC filters 12G and 12D being contained inside the ceramic laminated substrate.

Moreover, in the present embodiment, the capacitors C1g, C2g, C1d, and C2d of the matching elements 13G and 13D are formed so as not to overlap with the inductors and capacitors of the LC filters 12G and 12D when seen from the top. In this way, the mixture of a signal between the transmission and reception lines can be more effectively prevented.

Furthermore, since the ground electrode G4 is disposed between the inductors Lg and Ld of the matching elements 13G and 13D and the

inductors and capacitors of the LC filters 12G and 12D, the interference between them can be effectively prevented. Also by the fact that the capacitors of the LC filters 12G and 12D, that is, the shunt capacitors GCu1, GCu2, DCu1, and DCu2, in particular, are formed in the vicinity of the lower layer of the ceramic laminated substrate, the same effect can be obtained. Since the inductors Lg and Ld and the capacitors C1g, Cg2, C1d, and C2d of the matching elements 13G and 13D are formed on the surface of the ceramic laminated substrate, also the disposition of the inductors Lg and Ld of the matching elements 13G and 13D so as to be next to the capacitors C1g, C2g, C1d, and C2d of the matching elements 13G and 13D not through other elements can prevent mutual interference in the same way.

Moreover, in the present embodiment, the ground electrode G4 is also disposed between the capacitors C1g, C2g, C1d, and C2d and the inductors capacitors of the LC filters 12G and 12D. Thus, the interference between the both can be effectively prevented.

Furthermore, as shown in Fig. 8, on the surface of the ceramic multilayer substrate, the surface mounting parts constituting the matching elements 13G and 13D are disposed so as to be next to the surface mounting parts constituting the high-frequency switches 11G and 11D and the diplexer 20 through the surface acoustic wave filters SAWg and SAWd. When such a disposition is made, the interference between the matching elements 13G and 13D and the other elements can be more effectively suppressed.

Third embodiment (see Figs. 9 and 10)

A high-frequency composite part of the present third embodiment is a high-frequency composite part of a dual-band type having GSM and DCS systems in the same way as in the second embodiment, as its characteristic structure is shown in a block diagram in Fig. 9, and the capacitors C1g and C2g, and Cd and C2d are connected in series to the balanced output portions of the balanced-type surface acoustic

wave filters SAWg and SAWd and the inductors Lg and Ld are connected in parallel to the reception-side balanced output terminals Rxg and RXd.

Thus, the impedance of the first and second reception-side balanced output terminals Rxg and Rxd can be freely set and the impedance can be increased, in particular, in such a way that the capacitors C1g and C2g and the capacitors C1d and C2d are connected in series to the side of the first and second surface acoustic wave filters SAWg and SAWd and that the inductors Lg and Ld are connected in parallel to the side of the first and second reception-side balanced output terminals Rxg and Rxd, respectively.

Moreover, in the present third embodiment, the circuit structure and operation except for the first and second matching elements 13G and 13D are the same as in the second embodiment and the overlapping description is omitted.

Fourth embodiment (see Figs. 11 to 15)

A high-frequency composite part of the present fourth embodiment is constituted as a high-frequency composite part of a triple-band type having a GSM system and a DCS system branching off into two reception-side balanced output terminals Rxd1 and Rxd2 as shown in an equivalent circuit diagram of Fig. 11.

That is, the GSM system contains a first high-frequency switch 11G, a first LC filter 12G, a balanced-type first acoustic wave filter SAWg, and a first matching element 13G. The structure and operation of the GSM system is the same as that in the above-described second and third embodiments and the overlapping description is omitted.

The diplexer 20 also contains the basically same structure as that in the second and third embodiments and, in addition, a capacitor Cant is connected between the first port P11 and the antenna terminal ANT and the connection point is grounded through an inductor Lant.

The DCS system is composed of a second high-frequency switch 11D',

a second LC filter 12D, and a second transmission-side input terminal Txd. The circuit structure of this portion is the same as that in the second and third embodiments and the overlapping description is omitted.

In the DCS system, the third port P33d of the second high-frequency switch 11D' is connected to a duplexer 14D, and the duplexer 14D makes the path of a reception signal branch into a second reception-side balanced output terminal Rxd1 and a third reception-side balanced output terminal Rxd2.

The second high-frequency switch 11D' selectively switches a signal path between the antenna terminal ANT and the second transmission-side input terminal Txd and a signal path between the antenna terminal ANT and the second and third reception-side balanced output terminals Rxd1 and Rxd2.

The second high-frequency switch 11D' is composed of the diodes DD1, and DD2 as switching elements, inductors DPSL1, DSL2, and DPSLt, capacitors DC5, DC6, DPCt, and a resistor DR1. The diode DD1 is connected between the first port P31d and the second port P32d so that the anode may be on the side of the second port P32d, and the anode is grounded through the inductor DPSL1 and the capacitor DC6. The control terminal Vc2 is connected to the connection point between the inductor DPSL1 and the capacitor DC6. Furthermore, a series circuit of the capacitor DPCt and the inductor DPSLt is connected between the first port P31d and the second port P32d so as to be parallel to the diode DD. The anode of the diode DD2 is connected to the first port P31d through the inductor DSL2, and the cathode is grounded through the capacitor DC5. The connection point between the diode DD2 and the capacitor DC5 is grounded through the DR1.

In the duplexer 14D, an inductor PSL2 is connected between a first port P41d and a second port P42d, and the connection point between the inductor PSL2 and the second port P42d is grounded through a capacitor

PC7. The second port P42d is connected to a second surface acoustic wave filter SAWd1. Furthermore, a capacitor DC7 is connected between the first port P41d and a third port P43d of the duplexer 14D. The connection point between the capacitor DC7 and the first port P41d is grounded through a capacitor Cj, and simultaneously the connection point between the capacitor DC7 and the third port P43d is grounded through the inductor DSL1.

A second matching element 13D1 is connected to the balanced output portion of the second surface acoustic wave filter SAWd1, and a third matching element 13D2 is connected to the balanced output portion of a third surface acoustic wave filter SAWd2. In the second and third matching elements 13D1 and 13D2, in the same way as in the second embodiment, the inductors Ld are connected in parallel on the side of the surface acoustic wave filters SAWd1 and SAWd2, and the capacitors C2d and C2d are connected in series between the inductors Ld and the reception-side balanced output terminals Rxd1 and Rxd2, respectively. The operation-effect is the same as in the second embodiment. Moreover, the second and third matching elements 13D1 and 13D2 may be made to have the same circuit structure as that of the third embodiment, and in this case, the same operation effect can be obtained as in the third embodiment.

Figs. 12 to 14 show the capacitor electrodes, stripline electrodes, etc., formed by a screen printing, etc., on each sheet layer constituting the ceramic multilayer substrate of a high-frequency composite part of the present fourth embodiment.

Various external connection terminal electrodes are formed on the first sheet layer 62a. A ground electrode G11 is formed on the second sheet layer 62b, and the electrodes of capacitors Cu1, Ct2, and DC6 are formed on the third sheet layer 62c to form a capacitance together with the ground electrode G11. A ground electrode G12 is formed on the fourth sheet layer 62d, and the electrodes of capacitors DCu1,

DCu2, Cj, GCu1, and GCu2 are formed on the fifth sheet layer 62e to form a capacitance together with the ground electrode G12.

The inductors Lt1, Lt2, DLt1, DLt2, GLt1, GSL2, DSL2, and PSL2 are formed on the eight sheet layer 62h by using stripline electrodes. Inductors GSL2 and Lt1 are formed on the ninth sheet layer 62i by using stripline electrodes and connected to the electrodes on lower layers through via holes.

The inductors Lt1, Lt2, DLt1, DLt2, GLt1, GSL2, DSL2, and DSL2 are formed on the tenth sheet layer 62j by using stripline electrodes and connected to the electrodes of the same kind on lower layers through via holes. Inductors Lt1 and GSL2 are formed on the eleventh sheet layer 62k using stripline electrodes and connected to the electrodes of the same kind on lower layers through via holes.

The inductors Lt2, DLt1, DLt2, GLt1, GSL2, and DSL2 are formed on the twelve sheet layer 62l by using stripline electrodes and connected to the electrodes of the same kind on lower layers through via holes. The electrodes of the capacitors Ct1 and DCc2 are formed on the thirteenth sheet layer 62m, and the electrodes of the capacitors Ct1 and Cc1 and the ground electrode G13 are formed on the fourteenth sheet layer 62n. The electrodes of the capacitors DC5, Ct1, Cc1, GCc1, GC5, DCu1, and DCc2 are formed on the fifteenth sheet layer 62o. The electrodes of the capacitors Cc2 and CCc1 and a ground electrode G14 are formed on the sixteenth sheet layer 62p. The electrodes of the capacitor DCc1 are formed on the seventeenth sheet layer 62q.

The surface of the nineteenth sheet layer 62s is the surface of the ceramic multilayer substrate 50, as is shown in Fig. 15, and various connection terminal electrodes are formed and the first to third surface acoustic wave filters SAWg, SAWd1, and SAWd2 and the diodes GD1, GD2, DD1, and DD2 are mounted thereon. Moreover, the inductor Lg and the capacitors C1g and C2g constituting the first matching element 13G and the inductor Ld and the capacitors C1d and

C2d constituting the second and third matching elements 13D1 and 13D2 are mounted thereon.

Moreover, on the surface of the ceramic multilayer substrate 50, the resistors RG and DR1 are mounted, the inductors Lant, DPCt, DPSLt, DSL1, and DPSL1 are mounted, and the capacitors Cant, DC7, and PC7 are mounted.

In the high-frequency composite of the present fourth embodiment, a reception signal can be switched to the second reception-side balanced output terminal Rxd1 and the third reception-side balanced output terminal Rxd2 by turning on and off the diode of the second high-frequency switch 11D'. The other basic operation is as is described in the second embodiment and the operation effect is also the same as in the second embodiment.

In particular, as shown in Fig. 15, on the surface of the ceramic multilayer substrate, the surface mounting parts constituting the matching elements 13G, 13D1, and 13D2 are disposed so as to be opposite to the surface mounting parts constituting the high-frequency switches 11G and 11D', the diplexer 20, and the duplexer 14D through the surface acoustic wave filters SAWg, SAWd1, and SAWd2. Such a disposition can further suppress the interference between the matching elements 13G, 13D1, and 13D2 and the other elements.

Fifth embodiment (see Fig. 16)

A high-frequency composite part of the present fifth embodiment is constituted so as to be of a triple-band type, as shown in an equivalent circuit of Fig. 16. The structure is basically the same as that of the fourth embodiment (see Fig. 11) and the operation effect is also the same as the fourth embodiment. What is different is in that the reception-side balanced output terminals Rxd1 and Rxd2 are separated by a diode switch 15D instead of the duplexer 14D.

In detail, the diode switch 15D is composed of diodes SDD1 and SDD2 as switching elements, inductors SID1 and SID2, capacitors SC1,

SC2, and SC3, and a resistor SR. A first port P51d is connected to the third port P33d of the second high-frequency switch 11D', and the other end of the capacitor SC3 one end of which is connected to the first port P51d is connected to the anode of the diode SDD2 through the cathode of the diode SDD1 and the inductor SID2.

The anode of the diode SDD1 is grounded through the inductor SID1 and the capacitor SC1, and a control terminal Vc3 is connected to the connection point between the inductor SID1 and the capacitor SC1. The cathode of the diode SDD2 is grounded through the capacitor SC2, and the connection point between the cathode and the capacitor SC2 is grounded through the resistor SR. The second port P52d connected to the anode of the diode SDD1 is connected to the second surface acoustic wave filter SAWd1. Furthermore, the third port P53d connected to the anode of the diode SDD2 is connected to the third surface acoustic wave filter SAWd2.

Sixth embodiment (see Fig. 17)

A high-frequency composite part of the sixth embodiment is constituted so as to be of a triple-band type, as shown in Fig. 17. The structure is basically the same as that of the fourth embodiment (see Fig. 11) and the operation effect is also the same as in the fourth embodiment. What is different is in that the surface acoustic wave filters SAWd1 and SAWd2 having unbalanced output ports are of an unbalanced type and the matching elements 13D1 and 13D2 connected to the unbalanced output ports are constituted as baluns.

Other embodiments

Moreover, the high-frequency composite parts according to the present invention are not limited to the above-described embodiments, but various modifications can be made without departing from the spirit and the scope of the invention.

For example, in the above-described embodiments, high-frequency composite parts of a single-band type, a dual-band type, and a triple-

band type were described, but the present invention can be also applied to high-frequency composite parts of a multi-band type of a quad-band or more-band type.

Furthermore, in the embodiments, although the LC filters 12, 12G, and 12D for attenuating higher-order harmonics are disposed between the high-frequency switches are 11, 11G, 11D, and 11D' and the transmission-side input terminals Tx, Txg, and Tsd, they may be disposed between the antenna terminal ANT (diplexer 20) and the high-frequency switch.

Industrial Applicability

As described above, the present invention is useful for a high-frequency composite part which can be utilized in a plurality of different mobile communication systems and, in particular, is excellent in that a desired impedance can be easily set and no matching adjustment to LNAs is required.